CLAIMS

1. A post-processing method for reducing artifacts in block-coded digital images, the method comprising:

a) dividing an input image into a plurality of image blocks;

b) for each image block, estimating global features of said image block by providing information on an average content of image edges along horizontal and vertical directions of said image block;

c) for each pixel of an image block under examination, estimating local features for said pixel by providing information on content of image edges along horizontal and vertical directions of an image area near said pixel; and

d) modifying a value of said pixel according to both said global features of the image block to which said pixel belongs and said local features of the image area near said pixel.

2. The method according to claim 1 wherein the modifying step includes:

d1) defining a set of predefined local features;

d2) determining degrees of coincidence of said local features of the image area near said pixel with each predefined local features of said set, said degrees of coincidence depending on said global features of the image block to which said pixel belongs;

d3) making the value of said pixel equal to a weighted average of the value of said pixel and of the values of neighboring pixels, with weight factors depending on said degrees of coincidence of said local features with each of said predefined local features.

3. The method according to claim 2, said step of determining the degrees of coincidence in step d2) includes performing a fuzzy calculation.

4. The method according to claim 3 wherein each of said predefined local features is associated with a respective group of predefined weight factors, and each of said weight factors is calculated as a weighted average of corresponding predefined weight factors

of said groups with weight coefficients depending on said degrees of coincidence of said local features with each of said predefined local features.

5. The method according to claim 4 wherein said step of estimating global features of the image block under examination provides for applying horizontal and vertical Sobel operators to pixels belonging to an image sub-block internal to said image block under examination.

6. The method according to claim 5 wherein said step of estimating global features of the image block under examination provides for adding outputs of the horizontal Sobel operators applied to each pixel of said image sub-block to obtain an accumulated output of horizontal Sobel operators, and adding outputs of the vertical Sobel operators applied to each pixel of said image sub-block to obtain an accumulated output of vertical Sobel operators.

7. The method according to claim 6 wherein said global features of the image block under examination are formed by said accumulated outputs of the horizontal and vertical Sobel operators.

8. The method according to claim 6 wherein said global features of the image block under examination are formed by an average of said accumulated outputs of the horizontal and vertical Sobel operators.

9. The method according to claim 6 wherein said step of estimating local features for a pixel of the image block under examination includes:

c1) considering a horizontal processing window containing the pixel under examination and neighboring pixels belonging to a same image line as the pixel and preceding and following the pixel;

c2) applying said horizontal Sobel operator to each pixel of the horizontal processing window to obtain a horizontal pattern of horizontal Sobel operator outputs;

c3) considering a vertical processing window containing the pixel under examination and neighboring pixels belonging to a same column of pixels as the pixel and preceding and following the pixel; and

c4) applying said vertical Sobel operator to each pixel of the vertical processing window to obtain a vertical pattern of vertical Sobel operator outputs.

10. The method according to claim 9 wherein said horizontal and vertical processing windows each contains five pixels that are centered at said pixel under examination.

11. The method according to claim 10 wherein step d2) provides for determining degrees of membership of each horizontal Sobel operator output of the horizontal pattern to a first fuzzy set "Small" and to a first fuzzy set "Big", evaluating activation degrees of a first set of fuzzy rules each associated with at least one predefined horizontal pattern of horizontal Sobel operator outputs, determining degrees of membership of each vertical Sobel operator output of the vertical pattern to a second fuzzy set "Small" and to a second fuzzy set "Big" and evaluating activation degrees of a second set of fuzzy rules each associated with at least one predefined vertical pattern of vertical Sobel operator outputs.

12. The method according to claim 11 wherein said step of determining degrees of membership of the horizontal Sobel operator outputs of the horizontal pattern to said first fuzzy sets "Small" and "Big" provides for determining a first and a second membership functions depending on said global features, and said determining degrees of membership of the vertical Sobel operator outputs of the vertical pattern to said second fuzzy sets "Small" and "Big" provides for determining a third and fourth membership functions depending on said global features.

13. The method according to claim 12 wherein said groups of predefined weight factors comprise groups of predefined horizontal weight factors and groups of predefined vertical weight factors, each fuzzy rule of said first set being associated with a

respective one of said groups of predefined horizontal weight factors, and each fuzzy rule of said second set being associated with a respective one of said groups of predefined vertical weight factors.

14. The method according to claim 13 wherein said weight factors comprise horizontal weight factors and vertical weight factors, said horizontal weight factors being determined by making a weighted average of the predefined horizontal weight factors with weight coefficients being formed by the activation degrees of the fuzzy rules of the first set, and said vertical weight factors being determined by making a weighted average of the predefined vertical weight factors with weight coefficients formed by the activation degrees of the fuzzy rules of the second set.

15. The method according to claim 14 wherein the value of the pixel under examination is modified by applying the horizontal weight factors to the values of the pixels in the horizontal processing window and applying the vertical weight factors to the values of the pixels in the vertical processing window.

16. A post-processing device for reducing artifacts in block-coded digital images, characterized by comprising:

first means supplied with an input image for estimating global features of an image block under examination, said global features providing information on an average content of image edges along the horizontal and vertical directions of said image block;

second means supplied with said input image for estimating local features for each pixel of the image block under examination, said local features providing information on content of image edges along the horizontal and vertical directions of an image area around said pixel; and

third means supplied with said global features and said local features for modifying a value of said pixel according to both said global features and said local features.

17. The device according to claim 16 wherein said first means comprises means for evaluating horizontal and vertical Sobel operator outputs of horizontal and vertical Sobel operators applied to pixels of an image sub-block internal to said image block under examination, and accumulator means for accumulating the horizontal Sobel operator outputs and the vertical Sobel operator outputs for each pixel of the image sub-block.

18. The device according to claim 17 wherein said second means comprises fourth means for evaluating vertical Sobel operator outputs of vertical Sobel operators applied to said pixel and to vertically-neighboring pixels preceding and following the pixel in the vertical direction, and fifth means for evaluating horizontal Sobel operator outputs of horizontal Sobel operators applied to said pixel and to horizontally-neighboring pixels preceding and following the pixel in the horizontal direction.

19. The device according to claim 18 wherein said third means comprises vertical filter means supplied with said vertical Sobel operator outputs and said global features for calculating a vertically-filtered value of said pixel depending on said global features, said vertical Sobel operator outputs and the values of said vertically-neighboring pixels, and horizontal filter means supplied with said global features, said horizontal Sobel operator outputs and said vertically-filtered value of said pixel for calculating a horizontally-filtered value of said pixel depending on said global features, said horizontal Sobel operator outputs and the vertically-filtered values of said pixel and said horizontally-neighboring pixels.

20. The device according to claim 19 wherein said vertical filter means comprises first fuzzy computation means supplied with said vertical Sobel operator outputs and said global features for evaluating degrees of coincidence of the pattern of vertical Sobel operator outputs with a set of predefined patterns of vertical Sobel operator outputs, said degrees of coincidence depending on said global features, a look-up table of predefined vertical filter coefficients each one associated to at least one respective predefined pattern of vertical Sobel operator outputs, a vertical filter coefficients composition means supplied with

said predefined vertical filter coefficients for generating a set of vertical filter coefficients which are a weighted average of the predefined vertical filter coefficients with weight coefficients formed by said degrees of coincidence, and a vertical filter supplied with said vertical filter coefficients and the values of the pixel and the vertically-neighboring pixels for providing at an output said vertically-filtered value of the pixel.

21. The device according to claim 20 wherein said horizontal filter means comprises second fuzzy computation means supplied with said horizontal Sobel operator outputs and said global features for evaluating degrees of coincidence of the pattern of horizontal Sobel operator outputs with a set of predefined patterns of horizontal Sobel operator outputs, said degrees of coincidence depending on said global features, a look-up table of predefined horizontal filter coefficients each one associated to at least one respective predefined pattern of horizontal Sobel operator outputs, a horizontal filter coefficients composition means supplied with said predefined horizontal filter coefficients for generating a set of horizontal filter coefficients which are a weighted average of the predefined horizontal filter coefficients with weight coefficients formed by said degrees of coincidence, and a horizontal filter supplied with said horizontal filter coefficients and the vertically-filtered values of the pixel and the horizontally-neighboring pixels for providing at an output said horizontally-filtered value of the pixel.

22. A post-processing method for reducing artifacts in a block-coded digital image, the method comprising:

dividing the digital image into a plurality of image blocks;

for each image block, estimating global features of said image block by providing information on content of said image block along horizontal and vertical directions of said image block;

for each pixel of the image block under examination, estimating local features for said pixel by providing information on content of an image area that includes said pixel and adjacent pixels; and

modifying the pixels of the image block under examination according to both said global features of the image block and said local features the pixels of the image block.

23. The method according to claim 22 wherein said step of estimating global features of the image block under examination includes:

applying horizontal and vertical Sobel operators to pixels belonging to an image sub-block of said image block under examination;

adding outputs of the horizontal Sobel operators applied to each pixel of said image sub-block to obtain an accumulated output of horizontal Sobel operators; and

adding outputs of the vertical Sobel operators applied to each pixel of said image sub-block to obtain an accumulated output of vertical Sobel operators.

24. The method according to claim 22 wherein said step of estimating local features for each pixel of the image block under examination includes:

applying said horizontal Sobel operator to each pixel of a horizontal processing window to obtain a horizontal pattern of horizontal Sobel operator outputs, the horizontal processing window containing the pixel under examination and neighboring pixels belonging to a same image line as the pixel and preceding and following the pixel; and

applying said vertical Sobel operator to each pixel of a vertical processing window to obtain a vertical pattern of vertical Sobel operator outputs, the vertical processing window containing the pixel under examination and neighboring pixels belonging to a same column of pixels as the pixel and preceding and following the pixel.